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1 Cross-sectional survey of parasite control practices on Thoroughbred and Standardbred training
2 yards in New Zealand.

3

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14

15 Abstract

16 Reasons for performing the study: Worldwide, there is growing concern regarding anthelmintic
17 resistance in equine parasites. In order to improve parasite control practices and reduce the
18 selection for resistant parasites, baseline data are required.

19 Objective: To describe the current parasite management and control practices used for racehorses.

20 Study design: Cross-sectional survey

21 Methods: Thoroughbred and Standardbred trainers were surveyed online regarding demographics,
22 parasite control methods, grazing management and quarantine and the use of faecal egg counts
23 (FEC), with questions stratified by horse type: racehorses (horses in training) and spellers
24 (racehorses on a break from training) and industry (Thoroughbred and Standardbred). Multivariable
25 logistic regression was used to examine associations with FEC use.

26 Results: In total, 234 respondents completed the survey for an estimated response rate of 16%. In
27 total, 50.5% of trainers treated horses on an interval treatment strategy and treated a median of 6
28 (interquartile range (IQR) 4 to 7) and 6 (IQR 4 to 8) times annually for Thoroughbred and
29 Standardbred racehorses, respectively. A total of 62.5% (130/208) of respondents reported seeking
30 veterinary advice for deworming products, and FEC had been done by 20.1% (39/194) of
31 respondents. The odds of a trainer doing FEC were 4 times higher if the trainer had consulted a
32 veterinarian, compared to those that had not.

33 Conclusions: This study has highlighted an industry-wide overuse of anthelmintic products and few
34 trainers were using surveillance based control strategies. The relationship between veterinarians
35 and trainers should be explored further to enhance information dissemination and implement
36 effective control strategies, to maintain horse health and delay the advance of anthelmintic
37 resistance.

38 Keywords parasite, management, control practices, anthelmintic resistance, racehorse

39 Introduction

40 Historically, the control of gastrointestinal parasites in horses has relied on regular treatment with
41 anthelmintic products [1]. However, the frequent use of anthelmintics combined with inappropriate
42 parasite management strategies and the limited choice of active ingredients has resulted in reports
43 of anthelmintic resistance in horses in multiple species of parasites [1-4]. The recommendation to
44 reduce the reliance on anthelmintics and consequently delay the advance of anthelmintic resistance,
45 through the use of surveillance-based control programs has been suggested [1; 5]. However, uptake
46 of this new strategy has been slow, and the regular treatment of horses in the racing industry is still
47 widely reported [6-9].

48 New Zealand is one of few racing industries worldwide where both Standardbreds and
49 Thoroughbreds are produced for racing. A previous study of parasite control practices in commercial
50 stud farms in New Zealand identified a reliance on anthelmintic products and few practices
51 identified that would delay the development of anthelmintic resistance on either Thoroughbred and
52 Standardbred stud farms [8]. While the majority of horses in New Zealand are kept on pasture,
53 Thoroughbred and Standardbred racehorses form a unique population by being intensively housed
54 and managed [10; 11], whereby limiting exposure to parasites on pasture. Despite this, studies have
55 identified the frequent use of anthelmintics without evidence of parasite burdens in Thoroughbred
56 training establishments in the United Kingdom [6; 12]. To date, similar studies have not been
57 undertaken in Thoroughbred racehorses in New Zealand nor have any studies investigated practices
58 in Standardbred racehorses.

59 In order to effectively implement the surveillance-based control strategy, it is imperative to
60 understand the current parasite control practices used within the racing industry and to identify
61 factors that are potentially inhibiting the uptake of the new strategy. Resistance to ivermectin was
62 recently identified in New Zealand in *Parascaris equorum* [13]. The various cyathostomine species
63 are still considered susceptible to ivermectin but benzimidazole-resistance is likely widespread in

64 this group [14]. There have been no reports of resistance to pyrantel in this country. The aim of the
65 study was to describe the current parasite management and control practices used for
66 Thoroughbred and Standardbred racehorses in New Zealand.

67 Materials and Methods

68 *Target population and survey method*

69 The target population for this study was Thoroughbred and Standardbred trainers registered with
70 New Zealand Thoroughbred Racing (NZTR) and Harness Racing New Zealand (HRNZ), respectively. An
71 online questionnaire was created using web-based software (survey Gizmo) for online surveys and
72 was available online from 7th July to 20th September 2014. Thoroughbred trainers were notified of
73 the survey through an automated email bulletin sent to members by NZTR. Trainers were notified
74 through a news item listed on the NZTR and HRNZ website and a reminder email was sent directly to
75 all trainers registered with NZTR (n=775) and HRNZ (n=690) five days before the survey closed.

76 *Survey design*

77 The survey design was similar to that described by Bolwell *et al.* [8]. Briefly, the survey consisted of
78 30 questions and the survey was divided into four sections that included: demographics of
79 respondents, parasite control methods, grazing management and quarantine, and use of faecal egg
80 counts (FEC). The survey was modified to capture practices specific to the management of
81 racehorses with regards to the keeping of racehorses (horses in training) and spellers (racehorses on
82 a break from training) and access to grass during turnout. Deworming measures for arriving and
83 departing horses included information regarding i) racehorses, ii) spellers, iii) horses that were sold,
84 but may be retained as racehorses or iv) horses that were retired and would no longer race. As
85 described previously, data were retained in the dataset if the industry information was complete
86 and at least one question regarding deworming practices had been answered [8].

87 *Statistical analysis*

88 Data were checked for errors and categorised where appropriate. Region was defined by the New
89 Zealand Racing classifications: Northern, including Northland, Auckland, Waikato and Bay of Plenty,
90 Central including Taranaki, Hawkes Bay, Manawatu and Wellington, and Southern, all regions in the
91 South Island. Non-parametric data were summarised with median and interquartile range (IQR)
92 throughout and categorical and binary data were summarised as counts and percentages, stratified
93 by industry and by horse type. As respondents could choose not to answer some questions in the
94 survey, and some questions allowed multiple answers, the denominator was different between
95 sections. Anthelmintic products were not stratified by industry or horse type. All descriptive
96 summaries were conducted in Stata version 12.

97 Logistic regression analysis was used to determine factors associated with the outcome of the use of
98 FEC by trainers. Non-normally distributed data were categorised into quartiles and pasture
99 management strategies were categorised into four frequency categories; >monthly, monthly,
100 <monthly and never. Exposure variables were screened and those with a likelihood ratio test of
101 $P < 0.25$ were selected for inclusion in a multivariable model. A preliminary multivariable model was
102 built using a manual backwards method of elimination in which variables were retained in the model
103 if the likelihood ratio test statistic was $P < 0.05$. To control for confounding, the number of horses
104 trained and industry was retained in the final model. Biologically plausible two-way interaction
105 terms between the main effect variables were considered in the multivariable model. Model
106 diagnostics were conducted using summary measures of the goodness-of-fit of the final model [15]
107 and the evaluation of the standardised Pearson's residuals and leverage scores. All logistic analyses
108 were conducted in Stata version 11.

109 Results

110 *Survey respondents*

111 A total of 284 survey responses were received, of which 39 were blank, eight were unusable and
112 three were completed by respondents not involved in Thoroughbred and Standardbred training;

113 resulting in 234 usable surveys. Based on an approximate figure of 1,465 trainers registered with
114 NZTR and HRNZ, the response rate of the survey was 16%.

115 *Demographics*

116 Most respondents (56.4%; 132/234) were involved in Thoroughbred training, or 41.5% (97/234) in
117 Standardbred training, and 2.1% (5/234) were described as training both Thoroughbreds and
118 Standardbreds. Trainers were located in the Northern (89/234; 38.0%), Central (49/234; 20.9%) and
119 Southern (96/234; 41.0%) regions. Most respondents were male (60.4%; 139/230), aged between
120 51-70 years (58.2%; 135/232), and most had been involved in the industry for 10 years or more
121 (Supplementary Table 1). Table 1 summarises the number and type of horses kept by respondents.
122 Two trainers kept spelling horses only, leaving 232 trainers with racehorses. Two trainers had horses
123 in active training (horses in work), but did not specify the number of horses that they did or could
124 train (n=230) and one trainer specified the number that they could train, but not the number that
125 they currently had in active training (n=231). Overall, 33 trainers did not report keeping spelling
126 horses (n=201).

127 *Parasite control methods*

128 Eighteen respondents did not complete the remainder of the survey, leaving a maximum
129 denominator of 216 for trainers with racehorses and 188 for trainers with spellers. When asked if
130 horses were treated for gastrointestinal parasites, two respondents did not treat either racehorses
131 or spellers, including the use of herbal products. Both of these trainers kept Thoroughbreds.

132 In total, 2.3% (5/215) and 5.4% (10/185) of respondents reported a worm-related illness in their
133 racehorses and spellers, respectively, and 7.0% (15/215) with racehorses and 8.1% (15/185) with
134 spellers were unsure if their horses had had a worm related illness.

135 Table 2 summarises the treatment strategy used by trainers, and the treatment interval. Trainers
136 reported using interval dosing for treating racehorses (50.5%; 108/214) and spellers (50.5%; 95/188)

137 and 17.3% (37/214) treated racehorses and 14.4% (27/188) treated spellers on an interval specified
138 on the deworming product. In total, 6.1% (13/214) used a targeted strategy based on FEC for
139 racehorses and 4.8% (9/188) for spellers. Most trainers treated racehorses (46.7%; 98/210) and
140 spellers (37.8%; 70/185) routinely every 6-8 weeks. In the 12 months prior to the survey, racehorses
141 were dewormed a median 6 times annually for Thoroughbreds (IQR 4-7; max 15) and Standardbreds
142 (IQR 4-8; max 12), respectively. Spellers were dewormed a median of 4 times annually for
143 Thoroughbreds (IQR 4-6; max 15) and Standardbreds (IQR 4-6; max 12), respectively.

144 In the 12 months prior to survey, respondents used a median of 3 (IQR 2-4) anthelmintic products
145 (brands) to treat horses. Of the 212 respondents, four respondents did not know the product they
146 used to treat horses. There were a total of 32 products used to treat horses, with 16 ingredient or
147 ingredient combinations reported. In the 12 months prior to survey, respondents reported a total of
148 710 different treatment occasions based on anthelmintic product, with most treatments containing
149 a macrocyclic lactone (73.3%; 521/710). The most common anthelmintic ingredients used were
150 abamectin (26.5%; 188/710), ivermectin (27.9%; 198/710) and moxidectin (19.0%; 135/710).
151 Benzimidazoles were included in 42.3% (301/710) of anthelmintic products. When anthelmintics
152 ingredients were combined in a product, most treatment occasions included praziquantel (49.9%;
153 354/710), macrocyclic lactones in combination with benzimidazoles (20.1%; 148/710), macrocyclic
154 lactones or benzimidazoles in combination with pyrantel on (1.4%; 10/710) and (7.7%; 55/710) of
155 treatment occasions, respectively.

156 A total of 13.2% (30/212) of respondents reported using the anthelmintic ingredients of levamisole
157 or doramectin, products which are not licensed for use in horses. Four respondents reported using a
158 herbal product, in combination with other anthelmintics.

159 Oral treatments were used by 88.1% (104/118) and 82.4% (75/91) of Thoroughbred and
160 Standardbred trainers, respectively, rather than injectable or pour-on treatments. Most trainers
161 spent more than NZD\$50 per horse on anthelmintic treatment in the last 12 months; 67.8% (80/118)

162 and 64.7% (57/88) of Thoroughbred and Standardbred trainers, respectively. In total, 66.1% (78/118)
163 of Thoroughbred and 57.8% (52/90) of Standardbred trainers had consulted their veterinarian for
164 advice on deworming products.

165 *Grazing management*

166 Racehorses had a median of 8 (IQR 2-20) hours access to grass during turnout (time not spent in the
167 stable, stall, barn or yard) per day whilst in training, and spellers received a median of 24 (IQR 24-24)
168 hours access to grass per day. Grazing management by Thoroughbred and Standardbred trainers is
169 summarised in Figure 1.

170 In total, 65% (128/195) of trainers always dewormed spellers when they returned from other
171 properties and 71% (139/197) always dewormed new horses when they arrived at the training
172 establishment. The deworming practices used by trainers for arriving and departing horses are
173 shown in Figure 2.

174 *Use of FEC*

175 In total, 18.4% (20/109) Thoroughbred trainers and 22.2% (18/81) Standardbred trainers reported
176 using FEC; 53.8% when illness was suspected, 48.7% as part of regular testing, 23.1% when a new
177 horse arrived and 5.1% for other reasons. The frequency of FEC was not recorded. Two respondents
178 reported that they had identified anthelmintic resistance; one Thoroughbred and one Standardbred
179 trainer.

180 The industry, the number of horses in training, the frequency of harrowing and seeking veterinary
181 advice were all retained in the final model. When the number of horses in training and frequency of
182 harrowing were held constant, the odds of a trainer doing FEC was 4.25 (95% CI 1.54 to 11.69) times
183 greater if the trainer had consulted a veterinarian, compared to trainers who had not (Table 3). The
184 goodness of fit tests were non-significant and no values were removed from the final model due to

185 high residual, leverage or influential values. Univariable results are presented in Supplementary
186 Table 2.

187

188 Discussion

189 This study has provided baseline data on the parasite control practices utilised by racehorse trainers
190 in New Zealand and has identified a reliance on anthelmintic products, despite limited evidence of
191 parasitism in these horses or opportunity for infestation due to restricted access to pasture for
192 racehorses in active training. A surveillance-based control strategy is now considered to be the best
193 way to control parasites in horses and slow the development of anthelmintic resistance [2; 16].

194 However, the findings of the current study alongside the frequent treatment of horses on
195 commercial stud farms [8] is indicative of a systemic failure in the dissemination and/or the uptake
196 of surveillance based control strategies.

197 Half of both Thoroughbred and Standardbred trainers were utilising an interval regimen for spellers
198 and racehorses. The reliance on the interval strategy is consistent with previous studies of
199 Thoroughbreds and Standardbred stud farms in New Zealand [8; 14]. Similarly, the median number
200 of treatments horses received annually was comparable to the number of treatments on stud farms,
201 with racehorses treated as frequently as yearlings at up to 15 times annually [8]. Worldwide, the
202 treatment of Thoroughbreds at intervals and with a high frequency is commonplace in training
203 establishments [6; 12] and stud farms [6; 7; 9]. However, the concern is the systematic overuse of
204 anthelmintic products occurring industry-wide, and the future implications of these practices.

205 Macrocyclic Lactones were the most commonly used family of anthelmintics used by respondents in
206 the current study, with abamectin and ivermectin the most commonly used. This is consistent with
207 previous studies [7; 17]. While it is unclear what factors are driving trainer's choices of anthelmintic;
208 product availability, economics, efficacy or knowledge of anthelmintic resistance, it does raise

209 concerns regarding the selection for parasite resistance to the macrocyclic lactone anthelmintics.
210 There are emerging reports of resistance to the macrocyclic lactones, with studies reporting
211 shortened egg reappearance periods when horses were treated with this family of anthelmintic [18-
212 21], rather than reduced efficacy immediately post-treatment in FEC reduction tests [21]. Consistent
213 with a previous study from New Zealand [8], 13% of trainers reported the off-licence use of
214 anthelmintics, including levamisole and doramectin. The former is poorly safe for use in horses [22]
215 and in the latter the efficacy is unknown when given as an injectable preparation [23]. In the current
216 study, 4% of trainers reported dosing horses using injectable products despite no products being
217 licensed for this route of administration for horses in New Zealand. Similarly, pour-on products are
218 not licensed for use in horses in New Zealand.

219 Racehorses in the current study had limited, or no access to grass, compared to spelling horses,
220 which were at pasture all the time. In a study of training yards in the United Kingdom, 7% of horses
221 had no access to pasture [24], while in previous studies in New Zealand, only 50% of racehorses had
222 access to pasture [11]. At least fortnightly, one-third of trainers removed faeces from paddocks and
223 15% rotated horses between paddocks. Hillyer et al. [24] reported regular rotation of paddocks by
224 25% of trainers. Faeces removal has been reported in the United Kingdom as being practised
225 regularly by 12% of trainers [24], at least weekly by 44% of trainers [12] and 51% of trainers reported
226 removing faeces, but not necessarily often enough to avoid pasture contamination [6]. The removal
227 of faeces, the rotation of paddocks and the use of cross-grazing may serve to reduce pasture
228 infectivity and thus may ultimately slow down the development of anthelmintic resistance.
229 However, these practises could also be seen as a considerable constraint on the potential for a
230 refugia on pasture, potentially increasing selection for anthelmintic resistance when high treatment
231 frequencies are maintained [25]. The lack of refugia on pasture, combined with the frequent
232 movement of racehorses [26-28] and the inconsistent application of deworming procedures applied
233 to horses arriving at stud farms [27] or by racehorse trainers, indicate that once anthelmintic

234 resistance develops, resistant parasites would be likely to be spread throughout the racing
235 population.

236 The response rate in the current study is comparable to previous studies of the racing industry [8;
237 29] and this group of respondents had previously indicated their preference for email or online
238 contact [29]. The distribution of respondents, both in age, experience and geographically are
239 representative of the underlying populations of Thoroughbred and Standardbred trainers [11; 26;
240 30]. While this study has identified that practices are relatively uniform between industries and
241 between breeding and training facilities [8], care should be taken in interpreting the generalizability
242 of these results and further work should be undertaken in this area.

243 In order to implement changes in the current parasite control practices to surveillance based control
244 strategies, trainers will require evidence of financial benefit and effectiveness. Lester *et al.* [31]
245 estimated that a surveillance based control strategy of treatment with ivermectin or pyrantel
246 following a FEC of greater than 200 eggs per gram would be financially beneficial compared to an
247 interval strategy based on quarterly treatments of either moxidectin (two treatments) or moxidectin
248 and praziquantel and no FEC. The additional cost of conducting FEC was offset by a lower frequency
249 of anthelmintic treatment and treatment with cheaper products. While only 5% of trainers were
250 using FEC as part of a targeted control strategy, 20% of trainers were using FEC within their training
251 establishment. Therefore there is scope to increase the use of FEC for parasite control.

252 Unlike some European countries where the sale of anthelmintics for horses is restricted and most
253 horse owners purchase anthelmintics from veterinarians [32], the purchase and use of anthelmintics
254 in New Zealand is not restricted. This study illustrates a knowledge gap in the control of parasites
255 and it is unclear which methods and sources trainers use to inform their choices regarding
256 anthelmintic use or anthelmintic resistance and whether and how trainers acted upon this
257 information. However, racehorse trainers who sought veterinary advice in relation to anthelmintic
258 products were more likely to conduct FEC compared to yards that did not seek veterinary advice.

259 The finding that trainers adopting practices that would reduce the reliance on anthelmintics were
260 also seeking veterinary advice suggests veterinarians can have a positive impact on parasite control
261 practices and may currently have an underutilised role regarding communicating best-practice
262 parasite control practices. The veterinarian-trainer relationship requires further exploration in order
263 to ensure effective dissemination of current and future knowledge.

264 Conclusion

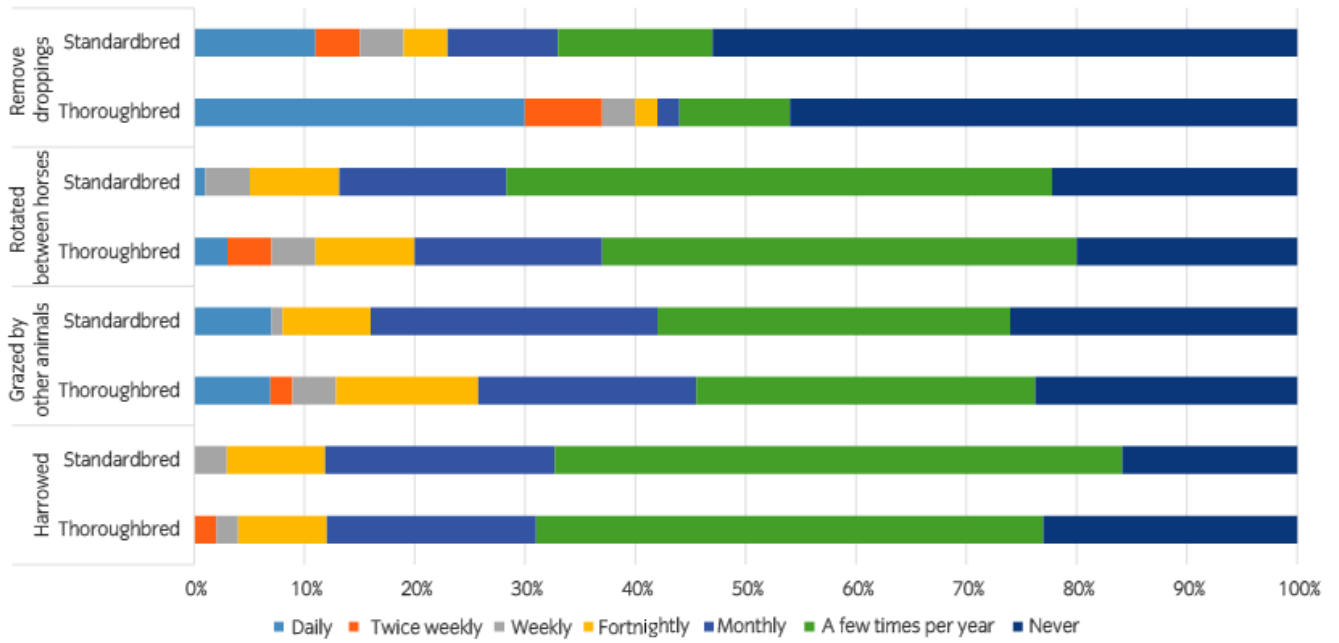
265 With low levels of disease attributed to gastrointestinal parasitism, limited access to parasites on
266 pasture and a high treatment cost per horse, it is difficult to advocate the continued use of interval
267 based parasite control strategies for horses in training. The current study has highlighted a high
268 reliance on anthelmintic use by both Thoroughbred and Standardbred trainers (for both spelling and
269 in training horses) and provides baseline information regarding control practices. The targeted
270 treatment of horses (based on positive FEC results) was limited despite surveillance-based control
271 strategies being widely advocated for equine parasite control. Currently, while trainers are
272 consulting veterinarians regarding anthelmintic products, best practice parasite control practices are
273 not being implemented by all trainers who seek advice.

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279 ID: PPH_01119).

280

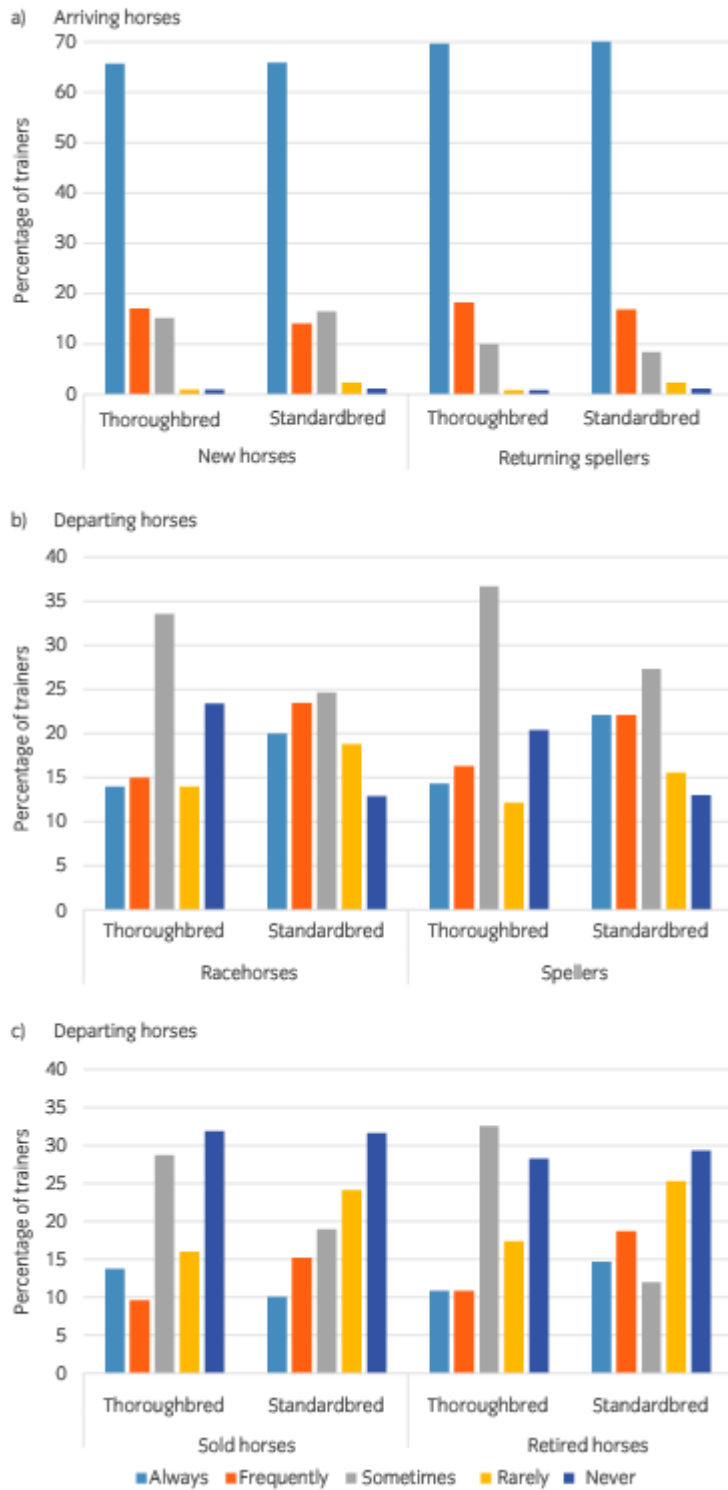
281 Figure 1: The frequency of harrowing, cross-grazing and rotating paddocks, and removing droppings
 282 as reported by respondents of an online survey of parasite control practices on Thoroughbred and
 283 Standardbred training yards in New Zealand (n=234)



284

285

286 Figure 2: The frequency of deworming arriving (A) and departing horses (B and C) as reported by
 287 respondents of an online survey of parasite control practices on Thoroughbred and Standardbred
 288 training yards in New Zealand (n=234)



289

290 Table 1: Description of the number of racehorses in training, racehorses trained and spellers kept by
 291 trainers, stratified by industry type. Data based on a survey of racehorse trainers in New Zealand
 292 (n=234).

Variable	Industry	Number of respondents (%)	Median	Interquartile Range	Maximum
Number in training^a	Thoroughbred	130 (98.5)	4	2 – 10	50
	Standardbred	97 (100)	4	2 – 8	46
	Both	4 (80)	4	3 - 4.5	5
Number trained^b	Thoroughbred	129 (97.7)	6	2 – 12	80
	Standardbred	96 (99)	4	3 – 10	60
	Both	5 (100)	10	6 – 12	13
Number of spellers^c	Thoroughbred	112 (84.8)	5	2 – 10	50
	Standardbred	84 (86.6)	4.5	2 – 10	510
	Both	5 (100)	4	2 – 4	10

293 ^a Two trainers kept only spelling horses and one trainer did not specify the number of horses in training.

294 ^b Two trainers only kept spelling horses and two trainers did not specify the number of horses they could
 295 train

296 ^c 33 trainers did not keep spelling horses

297

298 Table 2: Description of treatment strategy and treatment frequency used by trainers for racehorses and spellers, stratified by industry type. Data based on a
 299 survey of racehorse trainers in New Zealand. Interval dosing: at a set interval; strategic dosing: at specific times of the year; Deworming product: as often
 300 as recommended on the worming product; convenient: at a time convenient on the property; targeted: based on faecal egg counts.

Deworming practice	Level		Thoroughbred		Standardbred		Both		
			Number	Percentage	Number	Percentage	Number	Percentage	
Deworming strategy	Deworming product	Racehorses ^a	17	14.4	20	22.0			
		Spellers ^b	12	11.4	15	19.2			
	Interval dosing	Racehorses	61	51.7	45	49.5	2	40.0	
		Spellers	56	53.3	36	46.2	3	60.0	
	Strategic dosing	Racehorses	22	18.6	12	13.2	1	20.0	
		Spellers	16	15.2	13	16.7			
	Targeted	Racehorses	6	5.1	5	5.5	2	40.0	
		Spellers	6	5.7	1	1.3	2	40.0	
	Convenience	Racehorses	11	9.3	8	8.8			
		Spellers	14	13.3	12	15.4			
	Other	Racehorses	1	0.9	1	1.1			
		Spellers	1	1.0	1	1.3			
	Interval of treatment	Don't use an interval	Racehorses ^c	3	2.6	5	5.6		
			Spellers ^d	2	1.9	6	7.9	1	20.0
Less than 6 weeks		Racehorses	9	7.7	9	10.1			
		Spellers	7	6.7	2	2.6			
6 to 8 weeks		Racehorses	55	47.0	42	47.2	1	25.0	
		Spellers	41	39.4	28	36.8	1	20.0	
9 to 12 weeks		Racehorses	37	31.6	28	31.5	2	50.0	
		Spellers	41	39.4	22	28.9	1	20.0	
4 to 6 months		Racehorses	12	10.3	5	5.6	1	25.0	

	Spellers	12	11.5	17	22.4	2	40.0
7 to 12 months	Racehorses	1	0.9	0	0		
	Spellers	1	1.0	1	1.3		

301 Total number of respondents with racehorses was 216 and with spellers 188

302 ^a 2 missing values (n=214)

303 ^b 0 missing values (n=188)

304 ^c 6 missing values (n=210)

305 ^d 3 missing values (n=185)

306

307

308 Table 3: Multivariable logistic regression model of whether trainers used faecal egg counts. Data
 309 based on a survey of racehorse trainers in New Zealand (n=234)^a.

Variable	Level	Odds ratio	95% confidence interval	Wald P value	LRT* P value
Industry	Thoroughbred	REF			0.80
	Standardbred	1.17	0.50 – 2.74	0.72	
	Both	0.50	0.03 – 7.69	0.62	
Number of horses in training	0-2	REF			0.09
	3-5	0.98	0.29 - 3.32	0.97	
	6-11	0.82	0.23 - 2.95	0.76	
	12+	2.95	1.00 - 8.70	0.05	
Seeks veterinary advice about worming	No	REF			<0.01
	Yes	4.25	1.54 - 11.69	0.01	
Harrows paddocks	More than monthly	REF			<0.001
	Monthly	4.09	0.94 - 17.88	0.06	
	Less than monthly	0.63	0.15 - 2.70	0.53	
	Never	0.83	0.16 - 4.62	0.82	

310 *LRT = Likelihood ratio P value

311 ^atotal number of observations n=180

312

313

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